

## CHAPTER 12

### Broader Issues in the Offshore Fish Farming Debate

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*Previous chapters have been concerned primarily with the immediate and near-term implications of offshore aquaculture, such as markets, jobs, costs, and competition. This chapter looks at its potential over the longer term and within a broader context by asking:*

- *How does the potential of offshore aquaculture fit into the bigger picture of global food supply?*
- *What is its long-term potential and how important is this potential in evaluating today's efforts to get started?*
- *Since it is impossible to satisfy humanity's need for food with zero impact, how should offshore aquaculture be judged in comparison to other methods of food production?*
- *What new law, if any, is needed to enable private farming in marine public lands?*

#### The Global Food Supply

Discussion of the above questions becomes more meaningful when key points about global population and food supply are first understood: For example:

- Annual world food production in total is about 5.1 billion metric tons (Table 12.1).
- At least 1.1 billion tons (21%) of this food is fed to animals (Wild 1997)<sup>1</sup>.
- Production of terrestrial animal products is 473 million metric tons (mmt) per year.<sup>2</sup>
- Capture fisheries yield about 93 mmt of fish per year<sup>3</sup> (Figure 12.1).
- Aquaculture produces 42 mmt fish and shellfish per year, and 1.9 mmt of seaweed

Looking ahead, the FAO (2002) has projected that:

- World population will grow from about 6 billion people to 8.3 billion by 2030;
- Food calories available per person will increase from 2,800 kcal to 3,050 kcal;
- This means one billion metric tons more cereal crops will be needed for human and animal food; and
- 120 million hectares more farmland will be needed to grow these cereals.

FAO and other researchers also project that there will be an increase in per-capita consumption of meat and dairy products, which will be driven by higher per-capita incomes in

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<sup>1</sup> This figure is from a 1997 report. There are more up to date figures for the manufactured feed sector, but this is the only source the author could find that included all feeds, i.e. manufactured feeds (530 mmt), home mixing (350 mmt) and single ingredient feeds (220 mmt). Tacon (2005) quotes Gill (2005) in stating that manufactured feed production is now 620 mmt.

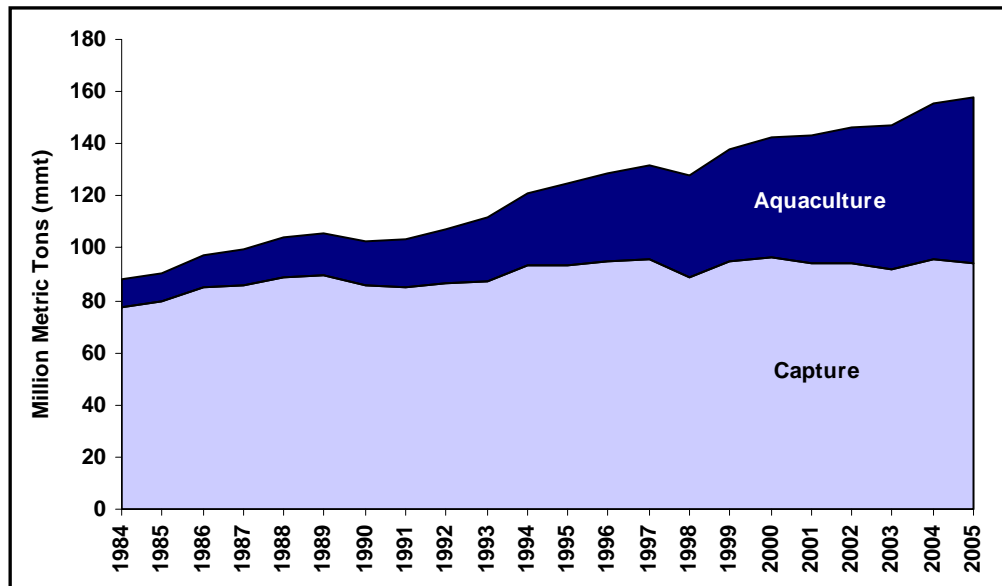
<sup>2</sup> This includes a 'constructed value' for milk of which there is 600 mmt produced each year. When expressed on a equivalent protein basis with meat using data from Waggoner (1994), this converts to 169 mmt.

<sup>3</sup> 68.3 mmt of which is eaten by humans and 21.7 mmt is made into fish meal.

**Table 12.1. Agricultural production in 1990.**

<i>Product</i>	<i>Production (mmt)</i>	<i>Protein (mmt)</i>
<b>CLASS 1</b>		
Wheat	601,723	84,162
Rice	521,703	46,953
Veg & melon	450,986	4,669
Fruit ex melon	344,875	2,811
Potatoes	268,107	4,547
Cassava	150,768	897
Sweet potatoes	125,124	1,709
Sugar	123,401	0
Pulses	58,846	13,117
Rye	40,042	5,606
Rapeseed	24,416	8,320
Ground nuts	23,410	4,440
Sunflower	22,682	7,729
Yams	20,966	379
Copra	5,476	394
Taro	5,173	82
Tree nuts	4,379	198
Roots other	3,971	54
Cocoa beans	2,528	437
Sesame	2,399	817
Olive oil	1,573	0
Honey	1,172	4
Safflower	917	312
<b>TOTAL</b>	<b>2,804,637</b>	<b>187,637</b>
<b>CLASS 2</b>		
Milk	537,844	18,836
Meat	176,629	26,222
Fish	99,535	24,585
Eggs	37,056	4,252
<b>TOTAL</b>	<b>851,064</b>	<b>73,895</b>
<b>CLASS 3</b>		
Corn	479,340	47,934
Barley	181,946	23,653
Soybeans	108,134	36,847
Sorghum	56,677	6,234
Oats	42,799	5,564
Cotton Seed	33,930	11,562
Millet	29,896	3,569
<b>TOTAL</b>	<b>932,722</b>	<b>135,363</b>
<b>GRAND TOTAL</b>	<b>4,588,423</b>	<b>396,895</b>

Note: More up-to-date data from various sources indicates that current world food production is more than shown here by about 500,000 mt. Data from Waggoner (1994) is used here because it is the only data that could be found that expressed global production in terms of weight and protein.

**Figure 12.1. Global seafood production from wild-capture fisheries and aquaculture.**

Source: FAO, 2007

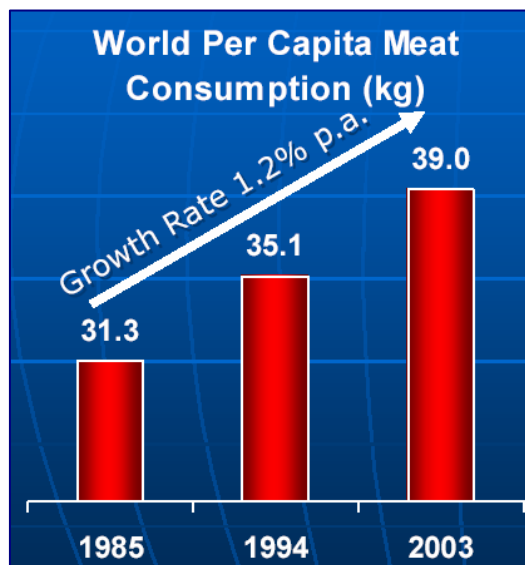
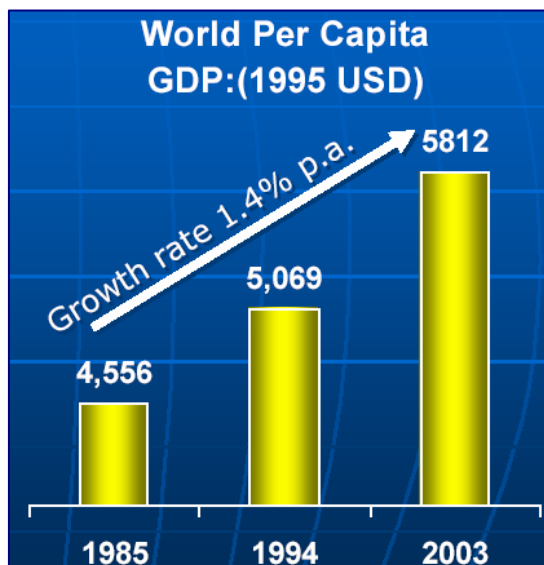
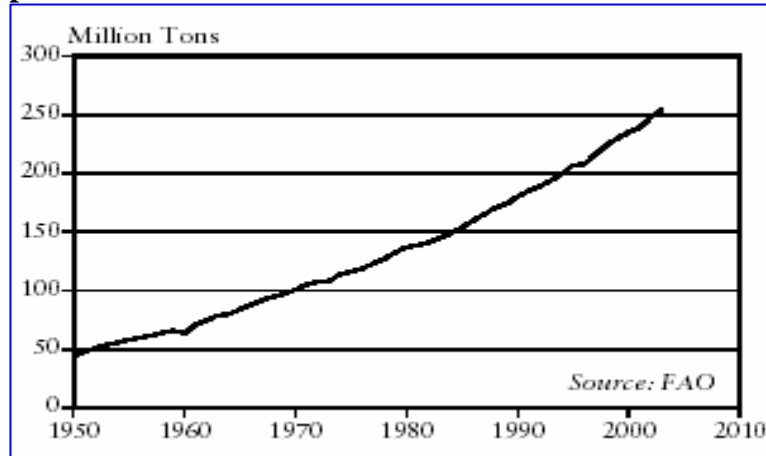
developing countries (FAO, 2002; Brown, 2005; Delgado et al., 1999) (Figure 12.2). Consumption of meat and milk by 2030 is expected to increase by 100 mmt and 223 mmt, respectively, led by China, which already consumes over twice the amount of meat eaten in America (Delgado et al., 1999; Brown, 2005). Delgado et al. (1999) also warn that unless increased production is accompanied by corresponding improvements in farming practices, it will result in continued environmental degradation including, importantly, continued diminution of fresh groundwater reserves.

These projections highlight the huge difference in the scale of production between what is anticipated by traditional agriculture and what might be feasible during the same period from offshore aquaculture. It is sobering to realize, for example, that just the expected increase in global meat supply between 1993 and 2030 is more than the present, total worldwide production of all seafood from capture fisheries and more than twice that of aquaculture. By comparison, the likely contribution from true offshore (open-ocean) aquaculture by 2030 will be modest. Presently, it contributes no more than about 20,000 mt per year worldwide<sup>4</sup> and, unless things go exceptionally well, this is unlikely to increase to more than 2 mmt by 2030, or by just 2% of the expected increase in meat supply. This does not mean it will never be more significant, but to reach its full potential, development of offshore aquaculture will take more than 25 years.

Under these circumstances, Delgado et al. (2003) conclude that prices for seafood, relative to other kinds of meat, will rise by about 20%. The primary driver for this increase will be demand in developing countries, which will occur because capture fisheries have reached the limit of what they can take from the oceans, while aquaculture is unlikely to be able to make up

<sup>4</sup> This estimate does not include 'nearshore' or sheltered water farming such as for salmon. It includes farmed tuna and limited quantities of other marine fish that are now being farmed in exposed open ocean (offshore) conditions.

**Figure 12.2. World meat production and the historical relationship between wealth and meat consumption .**



Sources: Brown, 2005, Bunge, undated

the gap. Moreover, demand for certain food crops to produce biofuel is now leading to price increases in a broad spectrum of food products worldwide. When superimposed on the outlook for seafood, this suggests even larger future seafood price increases as well as higher feed costs for those who grow any sort of livestock.

One final point that these numbers highlight is the vast disparity that exists between the amount of food derived from the land versus that captured from the sea. Presently, worldwide consumption of all animal products is 566 mmt per year<sup>5</sup>, of which the oceans contribute only 12.1%<sup>6</sup> from capture fisheries and less than 1% of our plant-derived food or fiber. Yet they cover over two-thirds of the Earth's surface and contain 97% of its water, and their natural productivity

<sup>5</sup> Total of 473 mmt of terrestrial animal products which, as noted in Footnote 2 of Page 1 (this chapter), includes a constructed value for milk protein, plus 93 mmt of seafood.

<sup>6</sup> 68.3 mmt of wild caught seafood was eaten by humans in 2003. This is 12.1% of the 566 mmt total.

is thought to be similar to that of the land, namely 40 to 50 pentagrams<sup>7</sup> (Pg) of carbon per year compared to 56 Pg per year on land (Geider et al., 2001). At a time when the world faces the prospect of having to produce large amounts of additional food by traditional agriculture, adding environmental burden to what is already thought to be excessive (UN, 2005), it is appropriate to ask: Is increased production of food from the oceans a possible solution and, if it is, what has to be done to accomplish it?

## **Offshore Aquaculture in the Long Term**

### *Making More Productive Use of the Sea*

The potential for offshore aquaculture in the long term may be larger and more profound than merely providing additional production to meet our future needs for seafood. Our biosphere is powered by energy received from the sun, two-thirds of which falls on the oceans. In turn, the oceans provide equable growing conditions for plant life over their entire surface, resulting in an overall level of productivity already comparable to that on land when, as yet, no serious attempt has been made to enhance it. Moreover, this productivity and its potential enhancement are not dependent on inputs of freshwater as is terrestrial agriculture, a dependency that may inhibit its expansion in some areas. The key to recovering more of this energy and to making the oceans more productive is to develop a system of aquaculture that grows plants as its primary source of production, with animal protein being produced secondarily, just as is done in terrestrial agriculture today.

For reasons explained below, it will take many decades and much experimentation before methods are perfected to be able to do this. Marine aquaculture, as practiced today, is simply a first stage in this process, and it is important that it is seen in this context because it is too easy, otherwise, to misinterpret it and to under-estimate the environmental and economic benefits it will bring. For the same reason, it is also important to start thinking about what might be involved in a plant-based “Marine Agronomy,” in order to help guide a development process that could not only ease pressure on our natural fisheries but could, eventually, reduce the demands we now make on the land and even on the biosphere itself. At a time when the prospect of global warming threatens human existence as we know it, it is surely an oversight that we use two-thirds of the Earth’s surface for little more than hunting and navigation.

Though agricultural parallels are persuasive, their application at sea is difficult, because terrestrial and marine ecosystems are quite different. While vegetation on land is dominated by large plants (macrophytes), plant life in the oceans consists mainly of microscopic plants, collectively called phytoplankton. Large marine plants (seaweeds) make up only a small proportion of total marine vegetation, because most seaweed species need to attach to a surface; normally the seabed. In order to do this and yet still receive enough light, they must occur in shallow water. Most of the ocean is too deep for them, so phytoplankton species - which can float near the surface in order to receive light - are the only plants that can grow there.

These tiny plants are the primary food source for higher animals, but they cannot be eaten directly by most fish and, instead, must first be consumed by small, filter feeding creatures specifically adapted for such a trophic existence. In turn, these creatures serve as food for larger

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<sup>7</sup> One pentagram = 10 to the power of 15 grams.

fish, some of which are captured in commercial fisheries, but which mostly provide forage for still larger fish that are then targeted for capture. Thus, the “marine food chain” requires one, two or more additional conversion steps compared to the process on land before producing animals that can be readily used by man. It means that most of the fish taken in capture fisheries, or contemplated as species for aquaculture, are carnivores, quite unlike the large macrophyte-eating herbivores that provide meat for humans on land.

There are exceptions to this; especially, bivalve shellfish that can filter and feed on phytoplankton and which humans are able to harvest directly. Future, large-scale ocean aquaculture could produce more shellfish for this reason. But there is probably a limit to how many mussels, oysters, or clams people can or want to eat. Mostly, humans prefer to eat fish and there are few species of fish suitable for farming, or palatable to humans, that can filter phytoplankton or eat seaweed. Therefore, a critical step in realizing the full potential of ocean farming is to figure out how to “shortcut” the natural marine food chain by processing protein and fat from marine plants so that they can be used in fish feed. Or, at least, to find uses for farmed marine plants that substitute for terrestrial ingredients in other applications. Unless this is done, fish farming will, in effect, be a “zero sum game” in which ingredients that might otherwise be fed to terrestrial animals are fed to fish instead. It is true that fish may convert these ingredients into meat more efficiently than warm-blooded land animals and that the meat itself may be of superior nutritional value, so the sum may not be exactly zero. But, the accomplishment will be so much greater if we can truly learn to amplify and harvest some of the ocean’s vast photosynthetic capacity.

#### *Seaweeds for biofuel and animal feed*

Increased food production is not the only way in which humanity might benefit. World energy use is expected to increase five-fold by 2100 (Huesemann, 2006). Given that peak oil production will soon be reached and that the continued combustion of fossil fuels will aggravate the many risks associated with global climate change, it is imperative that future energy demand be supplied by renewable energy. However, the generation of biofuels such as ethanol, diesel, and methane from terrestrial biomass requires extremely large areas of productive land. For example, to supply the current worldwide energy demand of 351 Exajoules ( $10^{18}$  joules)/yr solely with terrestrial biomass would require more than 10% of the earth’s land surface, which is comparable to the area used for the entire world arable agriculture; about 1,500 million hectares. Or, if ethanol from corn were to be substituted for 100% of the gasoline consumption in the U.S., all of the available U.S. cropland (190 million hectares) and the freshwater that irrigates it would have to be devoted to ethanol production, leaving no land for food production (Huesemann, 2006). Since the oceans are not used presently for any form of large-scale capture of solar energy by photosynthesis, it prompts the question: Could this be possible one day, and if so, could the resulting biomass be used for a wide range of applications, including biofuel production, thereby easing pressure on the land?

This idea was first examined in the early 1970s following the first world oil crisis when the U.S. Department of Energy and the Gas Research Institute established a marine biomass energy research program to determine the potential for producing methane from seaweed by a process of biodigestion. After conducting several pilot studies and feasibility analyses, Ashare et al. (1978) concluded that the concept was not then economically competitive, a conclusion that

was validated later as crude oil prices declined in the early 1990s. But oil and gas prices are now back at record highs and the prospect of carbon taxes makes it likely that burning them will become even more expensive in future. A recent analysis of the past work (Chynoweth et al. 2001) suggests that methane production from seaweed such as *Macrocystis*, *Sargassum*, and *Laminaria* could now be economically viable if methods can be developed for the large scale farming of these species. Viability might be even more likely if these plants could also be processed into products such as animal feeds as well as biofuel, as is the case in ethanol production from corn.

It is easy to dismiss such notions as fantasy. Certainly, the prospect of large scale farming of seaweeds for energy and animal feed is many years away but, as we learn to farm fish and to work in the open sea, so we will develop the skills and infrastructure that will allow us to farm marine plants there in future. And, as we learn to feed carnivorous fish on terrestrially grown plant nutrients, so we will set the stage for them to be fed, one day, on plant nutrients produced at sea.

In effect, today's pioneering aquacultural efforts are just the beginning of the creation of a critical mass around which new developments can take place, some of them barely imaginable now. The key to making progress, as it has always been, is to try, to risk failure and to learn from it. In a twenty-first century capitalist democracy, that also means trying something that has a chance at the outset of making some money and, for now, that means growing something for which people will pay a price that justifies the costs, and that means high value finfish. If we can embrace that idea and build research programs around it that anticipate subsequent steps in the journey, there is a reasonably good chance that it will get us, eventually, to where we need to go.

It is noteworthy that one of the companies that collaborated in the earlier marine biomass work was General Electric, which now, alongside other, international corporations, champions "green energy" production as one of the outstanding economic opportunities for American business in the new century. As in the offshore production of finfish, America possesses many of the technologies necessary to develop new, renewable energy and food sources based on the farming of marine plants. That such an opportunity is apparent at the same time as the offshore production of more seafood is contemplated is no coincidence. The Millennium Ecosystem Assessment (UN, 2005) describes all too clearly how the Earth, especially its terrestrial habitat, is strained to its breaking point. And though the assessment provides similar warnings about world fisheries and coastal pollution, it is not surprising that people from many fields find themselves wondering simultaneously if two-thirds of the planet could be used more effectively.

### First Steps

The Chinese philosopher, Lao-Tzu, once observed that a journey of a thousand miles must begin with a single step. Relative to the lofty goals put forward above, modern marine aquaculture has a long way to go and has, up to now, taken just a few tentative, albeit critical, steps for which it is often criticized. Salmon farming has borne the brunt of much of the criticism. Yet, in the space of only 30 years it has become the world's primary source of salmon and proved to a skeptical seafood industry that it is possible to turn to the sea and farm high-quality fish at a cost that meets the value expectations of a mass market. In so doing, it has made highly nutritious food available to many who would otherwise have been deprived of its benefits.

Of course, methods of salmon farming and the farming of other species can be improved. But these improvements would hardly be possible, or even contemplated, were it not for what was learned during the past few decades. Steady, incremental improvements in a technology may not satisfy idealists, but man has always progressed in this way and there is no reason to think that the development of ocean farming - be it for seafood, renewable energy, or other valuable byproducts - will be different. This is one of the reasons that the U.S. Commission on Ocean Policy and a wide variety of stakeholders have recommended the enactment of offshore aquaculture legislation: to enable the next steps in the process (NOAA, 2007; Cicin-Sain et al, 2005; Stickney et al, 2006). If America is to take the lead in this new industry, as it can and should, it is essential to provide a regulatory framework now that will allow a period of experiment and innovation to begin.

*What can be expected?*

If an initial timeframe of ten years is contemplated, what sort of projects can be envisioned, what will they look like, and how much space within the EEZ will be needed? Ten years is not very long in a business with production cycles from egg to harvest up to three years, so it is unlikely that within such time passing of legislation will unleash massive growth. The technical challenges and assembly of all the components needed to make medium to large scale offshore aquaculture business work are complex, so initial investment is likely to be cautious and painstaking. But it will lay the groundwork for further expansion and provide a more informed basis for further legislation should it be found that such is needed. The sorts of development that can be expected may include:

- Demonstration that offshore farming systems can be operated economically over several years in a wide range of sea conditions;
- Establishment of up to 20 new offshore farms in the U.S. EEZ, with a combined annual production of 10,000 to 15,000 mt;
- Identification of up to ten different species of fish as suitable candidates for offshore aquaculture;
- Establishment of up to five onshore hatcheries to produce juvenile fish to be stocked in offshore farms;
- Establishment and gradual expansion of offshore methods for the production of mussels and possibly scallops; and
- Research on techniques for farming and processing certain seaweeds, and on development of applications and markets for them.

It is important that this likely pace and nature of progress is understood clearly. To put it in perspective, an offshore aquaculture industry of 20 farms producing a combined total of 15,000 mt of fish per year would need about 30 acres of surface space in the EEZ for net pens, with up to 2,000 acres encumbered by moorings on the seabed (out of the 25 billion acres of the U.S. EEZ).

Looking ahead further, there are several directions the industry may take. Which of them will be followed and how quickly development proceeds will depend on the success of research and on markets as they evolve, but the following are some possibilities:

- Combined aquaculture and offshore wave or wind energy systems that tap the synergies created by supporting infrastructure and by wave attenuation in the case of wave energy;
- Location of farms in deeper water as single point mooring methods are perfected or self-positioning systems are developed that can be operated at any depth;
- Refinement in the understanding of how nutrients can be recycled from fish farms by integration with shellfish or seaweed farms;
- Adoption of offshore mussel farming (as in New Hampshire) and small finfish cage culture technologies by commercial fishermen using existing boats and supply high value niche markets; and
- Development of methods for the floating culture of seaweeds combined with genetic improvements in them like those that made the “green revolution” in terrestrial agriculture possible, yielding biomass of increasingly high value for a range of new applications, including renewable energy.

Such developments may herald a completely new method of energy and food production that could, one day, free humans from the limits of the land and allow some of the land itself to be taken out of production. This will not happen in committees, or through desk studies, but by learning-by-doing, through the hard work of pilot and demonstration projects, fledgling commercial operations, and by cooperative work of fishermen, entrepreneurs, scientists, and seafood businesses.

*How sustainable is it and how should this be judged?*

The long-term vision for ocean farming offered above would seem to meet all current definitions of “sustainable” since farming would be predominantly powered by sunlight. However, as noted, there is a long way to go before the vision will become reality. How, therefore, should sustainability be judged in the interim? In fact, how can the sustainability of any process be judged when it is not static but constantly adapting to change? Critics frequently brand some forms of modern marine aquaculture as unsustainable, notably salmon farming. But is this meaningful, or helpful, if such activities are a means to an end that will be quite different from the way they operate today?

Three presumptions seem to underlie the criticism. First, that there is little difference between fisheries, which depend on nature to adapt to and recover from human pressure, versus fish farming, where “nurture” allows man to intervene to accelerate the process using technology. An editorial in the February 9, 2006 *Seattle Times*, “Don’t throw more krill on the barbie,” captured this idea. Second, aquaculture will continue to expand unchecked by ecological or market forces. Third, the industry cannot be trusted to improve on its own. Yet the industry has been undergoing constant and rapid improvement for the past 30 years in response to ecological, market, and regulatory forces. By any standard, it is more efficient now than it was 30 - or even 10 - years ago, both economically and ecologically. And while regulatory coercion played a part, competition, smart design to save on costs, and rising prices of inputs such as feed costs, have been by far the greatest forces for change.

A frequently cited criticism, which embraces elements of all three presumptions, is that the use of fish meal in salmon feeds is unsustainable because fish meal fisheries are fished to their limit and cannot supply more. Further, it is argued that salmon and most marine fish are carnivores and that feeding them with fish is like feeding tigers with meat and leads to a net loss of fish protein (Naylor, et. al., 2000). The counter-points to this are listed below; each speaks in a different way to why these criticisms and the resulting charge of lack of sustainability are misleading.

1. Up to one-third of fish meal is made from fishery wastes that would have to be disposed of if not re-used as animal feed.
2. The other two-thirds are made mostly from small bony fish that are caught in mostly well-managed fisheries and for which man has not yet found a better use. In fact, implied in much of the criticism on this issue is the idea that using these fish for fish meal production deprives malnourished people from being able to eat them instead. This is highly misleading because it has proved impossible up to now, despite considerable effort, to process them into a form that is palatable to people at a cost that makes sense.
3. Feeding salmon with some fish meal in their diet is actually up to five times more efficient than if the fish from which the meal is made were left in the sea to be eaten by wild fish (Asgard et al., 1999). Thus, the idea that use of fish meal in aquaculture results in a net loss of fish protein is also misleading.
4. The comparison with feeding tigers overlooks the fundamental differences between marine and terrestrial ecosystems (explained earlier) and the last two points made. The great majority of fish that humans eat are carnivores, but whereas for commercially-caught wild fish this can never change, in aquaculture it can and will. Indeed, changes are already happening (see #6 below).
5. Because an animal has adapted to catch and eat other animals in nature does not mean that its digestive system is incapable of using vegetable matter, especially if the protein in this matter has been concentrated (Rust, 2002). Thus, in captivity carnivores can in effect be turned into herbivores. There is still much to learn about doing this with many potential aquaculture species, but carnivorous behavior in nature is not an immutable physiological state.
6. Salmon farmers and farmers of other carnivorous fish have realized for years that the supply of fishmeal is finite and that this represents a commercial vulnerability. Research to find alternatives has been progressing since the 1970s, and ingredients such as soy, corn, and canola protein are already being used in salmon feeds at increasing rates of inclusion.

In a broader context and building on what has been learned in the last 20 years, most people would say that commercial offshore aquaculture was not only sustainable, but highly beneficial if, 25 years from now, it becomes an industry that:

- contributes one mmt (\$2.5 billion) of domestically-produced seafood to the national larder;
- demonstrates that it really is a means to reduce pressure on over-fished stocks;

- is well on its way to perfecting ecologically balanced aquaculture that recovers wastes from fish farms through secondary production of shellfish and seaweeds; and
- uses feed made from all vegetable proteins or byproducts from other agribusinesses, while developing methods for making feeds directly from seaweed proteins.

And, while some may challenge that controlled recycling of fish farm wastes in an ocean environment is improbable, it is not so very different from the concepts of organic agriculture today, where farm animals are nourished with feed that is grown in fields nearby using animal wastes as the primary source of nutrients. A major difference between the two is that, on land, such wastes have to be collected, transported and spread, using non-renewable energy for a process that at sea is performed passively. Given the vastness of the oceans and with careful siting of aquaculture operations, aquaculture could transform man's present understanding of the Earth's productive capacity and possibly reduce the burden he currently imposes on its exhausted lands.

### Environmental Costs

Some of the discourse about marine aquaculture is focused upon concerns about actual or hypothetical environmental impacts. It is suggested, however, that it would be better instead to talk about environmental costs or the use of environmental services. Man could not survive without incurring such costs or using such services, and it is hardly surprising that the costs imposed by six billion people (soon to be eight billion) appear to be pushing the environment toward bankruptcy—consumption of food being one the main drivers. Yet no one suggests that humans should not eat, so the only solution, if there is one, is to seek to minimize the costs incurred or services used in producing what we need.

This raises two points of principle which merit discussion and which; as is often the case in debate about aquaculture, take the discourse into a much broader realm of philosophy and man's purpose in life. First, though we are confronted by great environmental challenges, is it an appropriate response merely to try to conserve rather than to seek instead to manage and build on the resources that have been given to us? Second is the concept of relative costs, or comparative ecological footprints. As we strive to build on our resources, there will be environmental costs and risks that things will not always go as expected. There is no hiding from the fact that in the short and medium term, as an offshore aquaculture industry strives to develop it may (like any aquaculture operation elsewhere) incur ecological costs, including:

- use of feed materials from several external sources;
- discharge of wastes into marine waters;
- the potential for escapes of domesticated stock which, if they breed with wild stock, may impact them genetically; and
- the potential for release of pathogens if farmed stock become infected, which may then heighten the risks of disease in wild stock.

All of these actual or potential costs will either draw on environmental services or risk negative environmental consequences. But are these more or less than the burdens imposed by other forms of food production, such as deforestation or soil erosion in terrestrial agriculture, or degradation by certain commercial fisheries at sea? It is impossible to satisfy humanity's need

for food with zero impact. Therefore, in weighing the possible impacts of a new form of food production—such as offshore aquaculture—the alternatives must be compared.

Offshore aquaculture is opposed or criticized by parts of two general constituencies: the commercial fishing industry and environmental NGOs. The commercial fishing industry is concerned about aquaculture being a competitive source of supply and about possible environmental consequences that could threaten the resource it harvests. Environmental NGOs also worry about environmental issues and about setting in motion an industry whose future scale and consequences are unknown.

To address these concerns, we need a dispassionate comparison between commercial fishing, aquaculture, and other forms of food production and of the role that aquaculture can play in an integrated approach to managing marine ecosystems. We also need a better understanding of the synergies between fishing and aquaculture, how fishermen can benefit from aquaculture, and of the effects of the globalization of the seafood trade on U.S. production of seafood. Today's clamor for sustainability will eventually ensure that such matters are addressed and that those on all sides are judged without prejudice.

### **Private Use of Marine Lands**

In its final report, "An Ocean Blueprint for the 21<sup>st</sup> Century," the U.S. Commission on Ocean Policy offers a primer on ocean jurisdictions under the title, "Drawing Lines in the Water". In general, both the states and the federal government must exercise authority over the nation's waters "for the benefit of the public" under *The Public Trust Doctrine*, which originates from ancient Roman and English common law. Given such ancient origins, it is hardly surprising that the obligation that the doctrine imposes has had to be interpreted, modified, and adjudicated numerous times in response to new circumstances, and there is a large body of law to reflect this work.

Aquaculture in marine waters introduces another new circumstance that could not have been foreseen in earlier interpretations of the doctrine and for which a new body of law will have to evolve. In the same way that society has evolved rules to govern rights to use of the airwaves for communication, the skies for air transport, the sea for commercial fishing and the sea bed for mineral extraction, it is also clearly possible to provide new laws for offshore aquaculture. But this pre-supposes that the political will to do so exists.

As the process moves forward, however, it is possible to imagine certain outcomes and to respond proactively to some concerns. First, for offshore aquaculture to succeed, small parts of the EEZ will need to be privatized, albeit through permits rather than titled ownership. In other words, government has to act as a partner in this development because government is the owner (*The Public Trust Doctrine* notwithstanding) of the aquatic real estate that will be farmed.

Parallels with the homesteading laws of earlier times are relevant here. In order to encourage settlement and productive use of western lands, the government provided not only permission but also incentive to those with the will and the drive to challenge a new frontier.

There are reasons to think that the oceans now represent such a frontier and, once again, it is government's task to act as both the enabler and the steward.

In this context, it is interesting to compare the development of the U.S. catfish farming industry with various approaches to sea-based aquaculture. On land (albeit land that is excavated to make ponds), land-use law and the principle of private property is clearly established. In fact, it is enshrined in our essential freedoms. Thus, there was little to deter landowners and traditional farmers in the South from digging ponds and becoming catfish farmers once they recognized this as good business. In other words, they were free, within reason, to do what they wanted with their land and they knew that their investment would be secure, and might even increase in value as commercial success was proved. The result is a world-class industry that now produces over 70% of all aquacultured products in America.

Examples of privately owned marine property are rare but they do exist. For example, tidelands in the State of Washington have been privately owned and used for shellfish farming since statehood, providing the owners with a bankable asset that appreciates in value. Private ownership has even been found helpful in some commercial fisheries, where allocation and subsequent ownership of fishery quotas provides the motivation to better husband the resource and manage the supply.<sup>8</sup> Such quotas are also bankable; in fact, selling quotas has provided some with a lucrative exit from the commercial fishing industry.

Since the days of claim-staking and unrestricted access to natural resources have passed, it is incumbent on government leaders to do three things:

1. Establish a schedule of permit fees that at one and the same time recover a fair rent for use of public waters, while acknowledging the commercial risk and the international competition that offshore fish farmers must deal with.
2. Establish ownership criteria that encourage local and national investment, while being consistent with international trade law and recognizing the reciprocal rights that Americans are usually accorded when investing overseas themselves.
3. Consider how the economic multiplier benefits of investment in offshore aquaculture can help those in coastal communities who are most in need, without imposing constraints that may inhibit the investment to begin with.

There are models and precedents for dealing with these matters in many branches of American commerce. Particularly relevant is the policy that makes federal lands available for the grazing of livestock, where fees are charged based on the number of animals the land will support. It is noteworthy that grazing occurs on 235 million acres of federal lands for a variety of purposes (GAO, 2005), which stands in marked contrast to the estimates provided earlier with regard to the surface and seabed areas required for aquaculture. It is to be hoped that, just because in this case we are dealing with the sea, the temptation will be resisted to re-invent wheels, and that existing practices—such as livestock grazing on public lands—can and will be used as models.

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<sup>8</sup> The most commonly use acronym for these today is LAPPs – Limited Access Privilege Programs.

An often heard comment in the discourse over marine aquaculture in America is that it can only work in countries with weak environmental regulations; that it will not develop in America because regulations here are too tough. This is not true. No business can operate in a lawless society, be it laws governing the environment or private property. Serious investors in aquaculture need tough environmental regulations and strong private property assurances to protect them from the capricious acts of government or criminal acts of individuals. The aquaculture industry is not looking for lax environmental standards or a free ride on the resources it uses, but instead, for regulatory clarity, certainty, and stability. State regulations already in place in Maine, Washington, Florida, and Texas, and regulations in other industrialized countries, provide good examples of what the industry expects and NOAA has in mind regarding environmental matters. Federal law that protects property rights from real estate to the air waves provides adequate prior guidance on which to base a fair and enabling system of marine leasing. If America is to take a lead in this new industry, as it can and should, its practitioners need and expect no less.

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